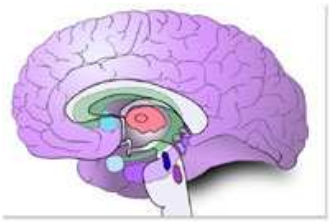
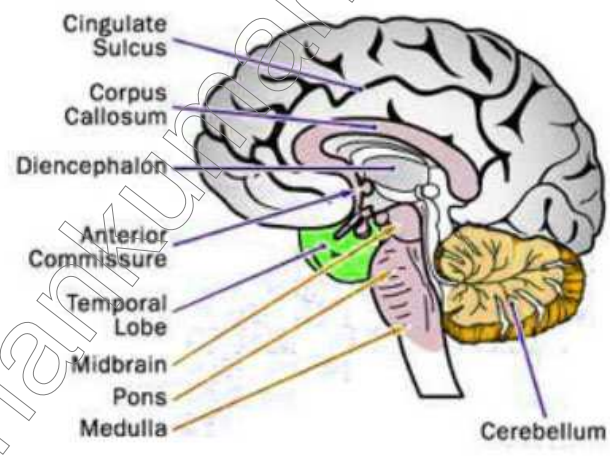
Functional MRI

Functional Magnetic Resonance Imaging or **fMRI** is the medical imaging technique used to measure **the haemodynamic response** of the brain in relation to the neural activities. fMRI is the advanced form of MRI Scanning which uses the magnetic resonance property of the nucleus of the atoms. It accesses the functions of the brain using the magnetic resonance property of haemoglobin.



The blood flow and oxygen transport in the brain are closely related. When the nerve cells in the brain are actively metabolizing, they consume more glucose and becomes less energetic and shift to **anaerobic Glycolysis**. The haemodynamic response to this brain activity causes more blood flow to the sites of increased activity. This changes the oxyhaemoglobin level of blood and local blood volume.



Internal Structure of Human Brain

Magnetic resonance

Magnetic resonance is the property of atoms to **vibrate** when subjected to a strong **magnetic field**. The MRI uses this property to **align** the **magnetization** of atoms in the brain cells using a strong magnetic field. The externally applied magnetic

field causes the nuclei of atoms to produce a **rotating magnetic field** which can be recorded. The strong magnetic field causes the rotation of nuclei at different speeds in different areas. The nuclei of active and inactive areas of the brain show difference in magnetic resonance, so it is easy to detect defective areas of the brain.

Haemodynamic response of Brain

The brain is composed of delicate nerve cells which utilize only glucose for energy production. The nerve cells do not store any glucose or oxygen and continuous supply of these materials is necessary for normal brain activity. The haemodynamic response of the brain is meant for rapid supply of oxygen and glucose to the sites of higher activities. As a result of the haemodynamic response, the blood releases more oxygen and glucose to **Neurons** and **Astrocytes** of the brain. This creates a higher **Oxyhaemoglobin – De-oxyhaemoglbin** ratio in the local areas of the brain.

Magnetism in tissues

Living tissue exhibits some magnetic property which is the character of **protons** and **electrons**. MRI exploits this magnetic property to identify **dead tissues** in organs. The MRI collects the signals from the **water protons**. In live tissue, water is abundant compared to dead tissue. This will help to identify the defective tissues. **Magnetic relaxation** in tissues can be increased using **Contrast agents** which can be introduced into the body intravenously to identify the areas of **hypervascularity**. The contrast agents contain **magnetic centers** that create a magnetic field very much higher than that of water protons.

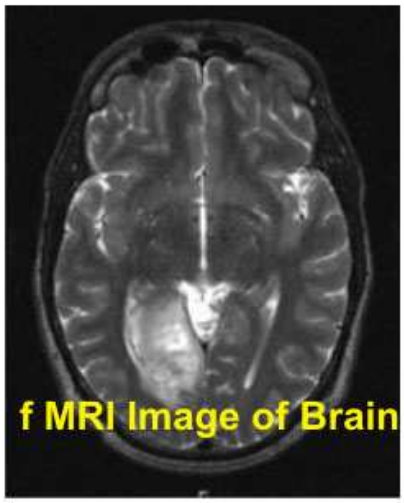
Haemoglobin is Dimagnetic and Paramagnetic

The haemoglobin molecule exhibits a magnetic resonance property and is **Dimagnetic** in the oxyhaemoglobin state and **Paramagnetic** in the de-oxyhaemoglobin state. Dimagnetism is the property to create a **magnetic field in opposition** to an externally created magnetic field thus causing a **repulsive effect**. The external magnetic field alters the **orbital velocity** of electrons spinning around the nucleus of the atom. This causes a change in the magnetic **dipole** movement. **Paramagnetic** property means the **ability of magnetism** in the presence of an external magnetic field. The paramagnetic materials have a magnetic permeability greater or equal to unity and hence attracted to magnetic fields.

Haemoglobin and BOLD

Haemoglobin is the major endogenous oxygen-binding molecule, responsible for binding oxygen in the lung and transporting it to the tissues by means of the circulation. Haemoglobin is the **Red colored** pigment in the blood which contains Iron which is always kept in the Ferrous state. That is why the haemoglobin is red in colour both in the oxidized and de oxidized states. When the haemoglobin combines with oxygen, it becomes oxyhaemoglobin and when it releases oxygen to the cells, it becomes De-oxyhaemoglobin. The parameter used in fMRI is **BOLD** (Blood-Oxygen-Level Dependence) which is the **relative concentration** of two states of haemoglobin like Oxyhaemoglobin and Deoxyhaemoglobin.

The Magnetic Resonance of the brain depends on the level of oxygen, so by collecting the data of magnetic resonance, it is easy to access the utilization of oxygen and glucose by the brain cells. That is, active cells use glucose and dead cells do not use glucose.



fMRI is a **Non Invasive** (Not causing injury) technique used to record brain signals without the risk of radiation as seen in CT or PET scanning. It gives a special resolution of 2-3 mm and can record signals from all parts of the brain and spinal cord. fMRI working is based on the **volumetric acquisition** of images with good **spatial** and **temporal** resolutions. Images are taken every 1-4 seconds and the **Voxels** (Voxel is the volume element, representing a value on a regular grid in three dimensional space. It is similar to **Pixel** in digital image) in the image represents tissues of 2-4 mm cube size.